NOνA
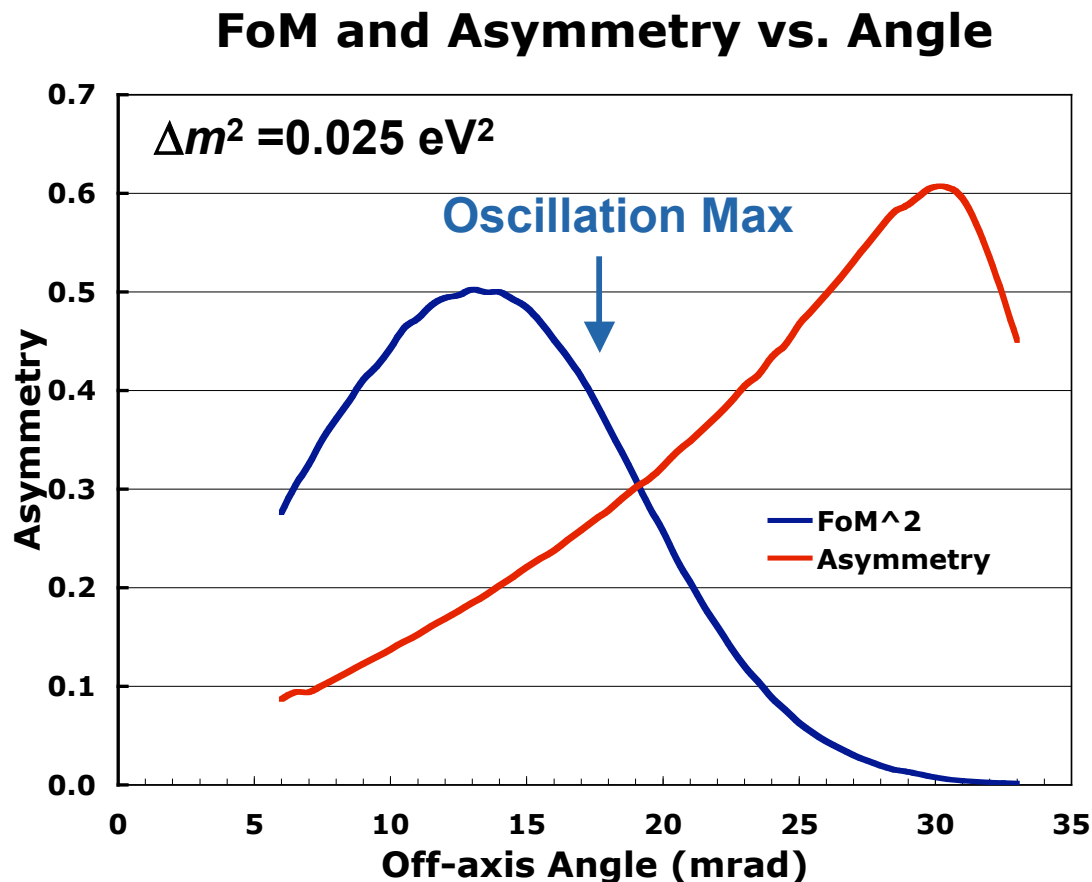
NOνA

3 April 2004

Gary Feldman

Q1: How would you change the baseline design to optimize for resolution of the mass hierarchy?

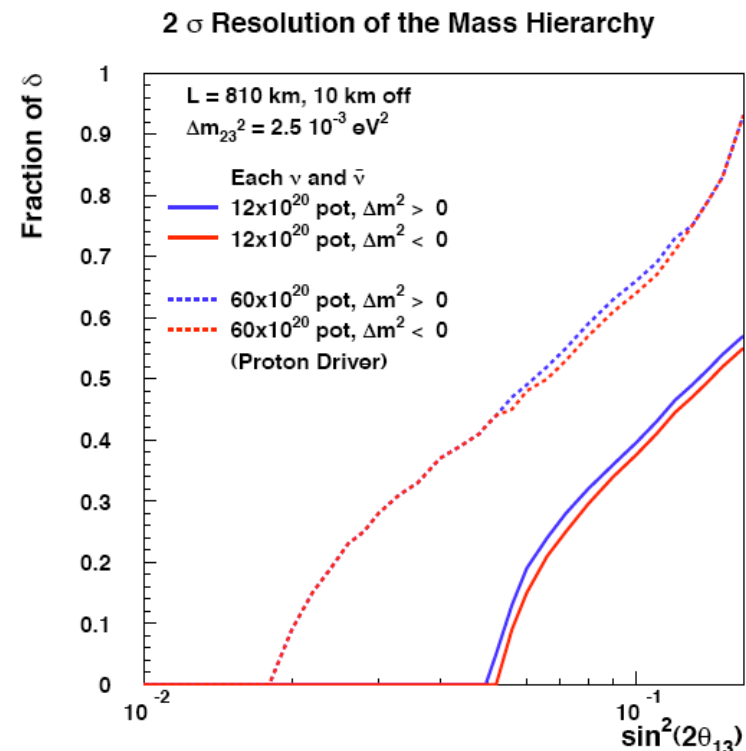**FoM and Asymmetry vs. Angle**

$\Delta m^2 = 0.025$ eV^2

Oscillation Max

Asymmetry (y-axis)

Off-axis Angle (mrad) (x-axis)

Legend:
— FoM^2
— Asymmetry

$$\text{Asymmetry} = \left(\frac{\sigma_\nu - \sigma_{\bar{\nu}}}{\sigma_\nu + \sigma_{\bar{\nu}}} \right)$$
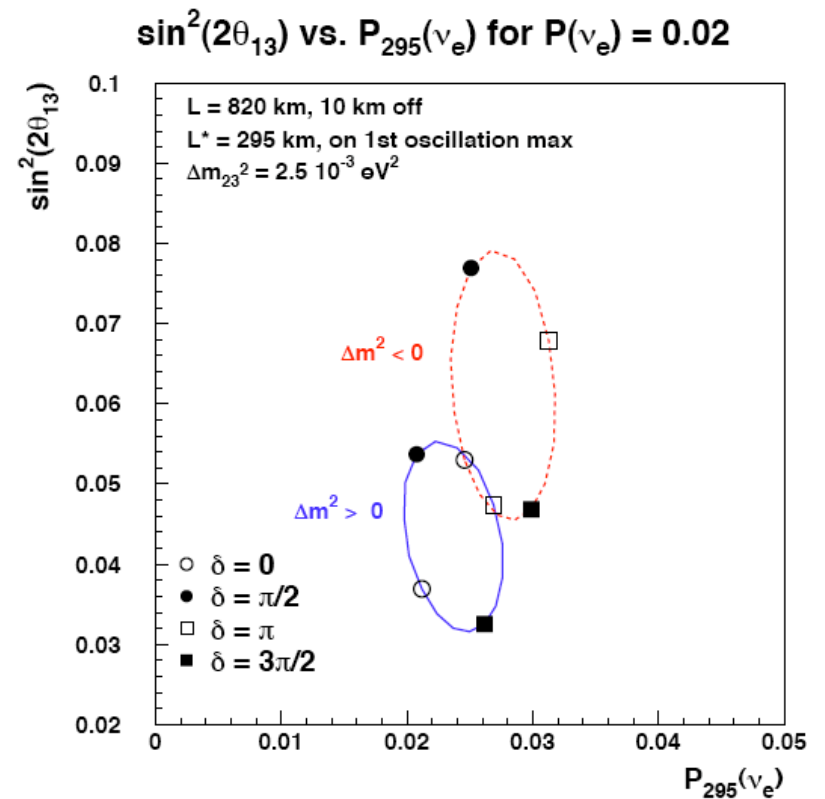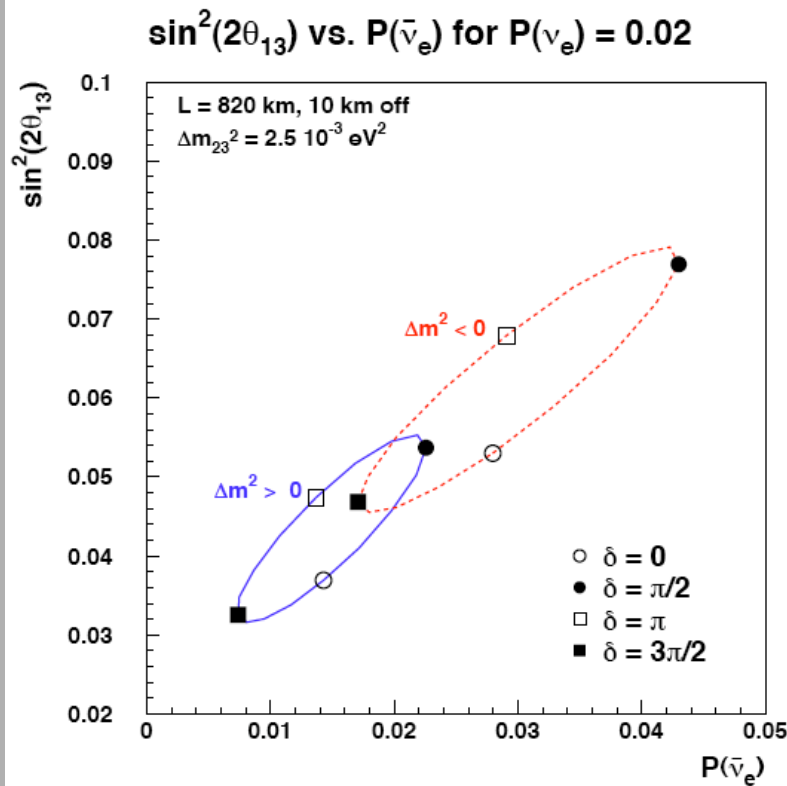
Answer: Move a few mrad further off axis.

NOνA

Q2: What is the unique science from NOνA if JPARC runs on schedule? (1)

- **Approximately the same sensitivity to observing $\nu_\mu \rightarrow \nu_e$ oscillations. There is a small parameter space in which NOνA could resolve the mass hierarchy. Some complementarity to JPARC.**

2 σ Resolution of the Mass Hierarchy

L = 810 km, 10 km off
$\Delta m_{23}^2 = 2.5 \; 10^{-3} \; eV^2$

Each ν and $\bar{\nu}$
—— 12×10^{20} pot, $\Delta m^2 > 0$
—— 12×10^{20} pot, $\Delta m^2 < 0$

---- 60×10^{20} pot, $\Delta m^2 > 0$
---- 60×10^{20} pot, $\Delta m^2 < 0$
(Proton Driver)

Fraction of δ

$\sin^2(2\theta_{13})$

NOνA

Q2: What is the unique science from NOνA if JPARC runs on schedule? (2)

NOνA

**Q3: When will details about the
fully active detector be available? (1)**

- **Probably on the scale of the technology decision, almost certainly not by Aspen.**

- **Two things are required:**

  - **The vertical slice test to verify liquid scintillator performance, and**

  - **Rather sophisticated simulations to take advantage of the higher quality information.**

- **The criterion is the FoM^2/$, where**

$$\text{FoM} = \frac{\text{signal}}{\sqrt{\text{background}}}$$

NOνA

**Q3: When will details about the
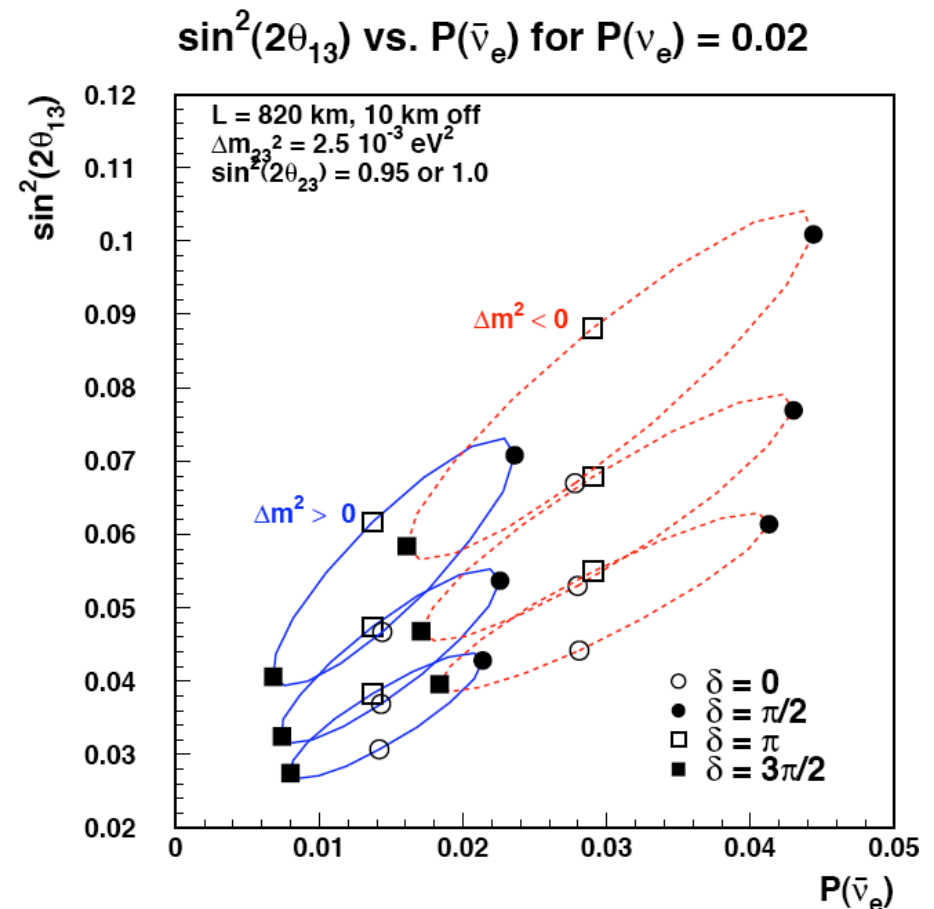fully active detector be available? (2)**

- **TASD optimizes differently than a sandwich detector. For example, the cells can be thicker, and thus longer. Some detailed estimates indicate that a 25 kt TASD will cost about the same as a 50 kt sandwich detector.**

- **In the present NOνA baseline simulation, the beam ν_e background is 50% of background.   Assume that the TASD ν_e background and signal efficiency scale together.**

NOνA

**Q3: When will details about the
fully active detector be available? (3)**

- **The baseline ν_e efficiency is 21%.**
- **To be competitive TASD must have a ν_e efficiency of**
  - **21% if the NC and ν_μ CC efficiency can be reduced to zero.**
  - **34% if the NC and ν_μ CC efficiency stay the same.**
  - **42% if the NC and ν_μ CC efficiency scale with the ν_e efficiency.**
- **Note that the baseline detects mainly quasi-elastic ν_e events, making increases in ν_e efficiency without increasing backgrounds difficult.**
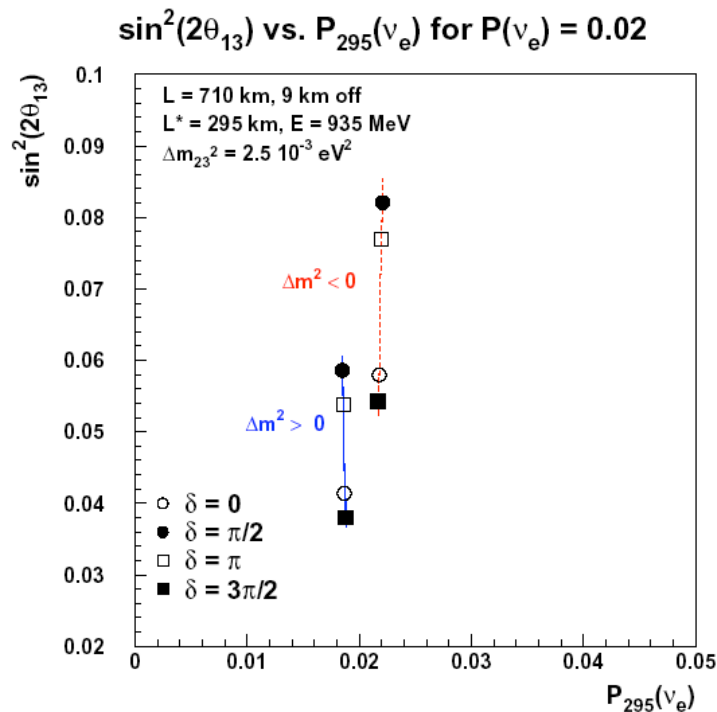
- **$\sin^2(2\theta_{23}) = 1.0$ or 0.95. Notice that the smearing is benign with respect to the mass hierarchy and the CP phase.**

$\sin^2(2\theta_{13})$ vs. $P(\bar{\nu}_e)$ for $P(\nu_e) = 0.02$

$L = 820$ km, 10 km off
$\Delta m_{23}^2 = 2.5 \cdot 10^{-3}$ eV^2
$\sin^2(2\theta_{23}) = 0.95$ or 1.0

$\Delta m^2 < 0$

$\Delta m^2 > 0$

○ $\delta = 0$
● $\delta = \pi/2$
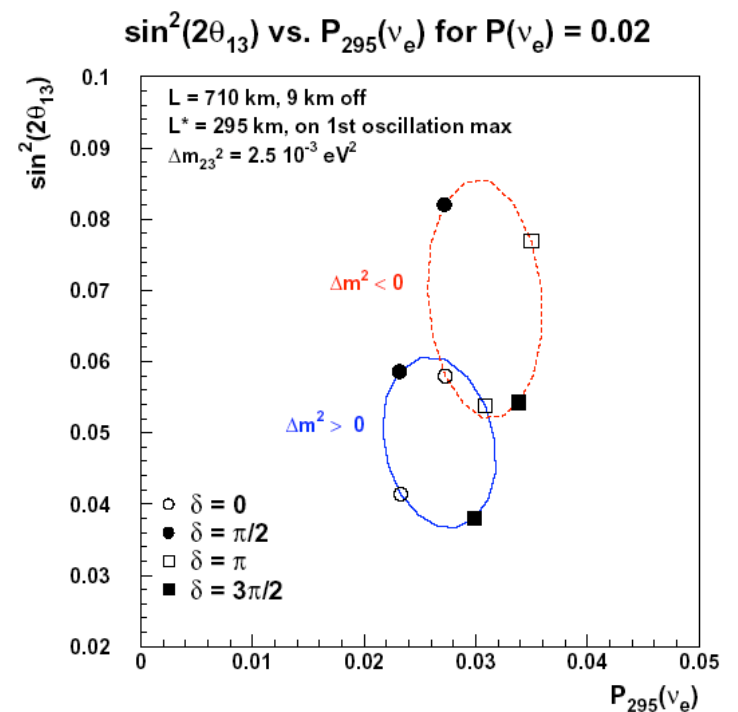□ $\delta = \pi$
■ $\delta = 3\pi/2$

NOνA

Q5: Do you have an example of two experiments at different baselines resolving the mass hierarchy by running only neutrinos?

- **The sentence in the proposal is from Steve Parke and points out that experiments at different baselines should run at the same relationship to the oscillation maximum.**

$\sin^2(2\theta_{13})$ vs. $P_{295}(\nu_e)$ for $P(\nu_e) = 0.02$

L = 710 km, 9 km off
L* = 295 km, E = 935 MeV
$\Delta m_{23}^2 = 2.5 \cdot 10^{-3}$ eV^2

$\Delta m^2 < 0$
$\Delta m^2 > 0$

○ $\delta = 0$
● $\delta = \pi/2$
□ $\delta = \pi$
■ $\delta = 3\pi/2$

$\sin^2(2\theta_{13})$ vs. $P_{295}(\nu_e)$ for $P(\nu_e) = 0.02$

L = 710 km, 9 km off
L* = 295 km, on 1st oscillation max
$\Delta m_{23}^2 = 2.5 \cdot 10^{-3}$ eV^2

$\Delta m^2 < 0$
$\Delta m^2 > 0$

○ $\delta = 0$
● $\delta = \pi/2$
□ $\delta = \pi$
■ $\delta = 3\pi/2$